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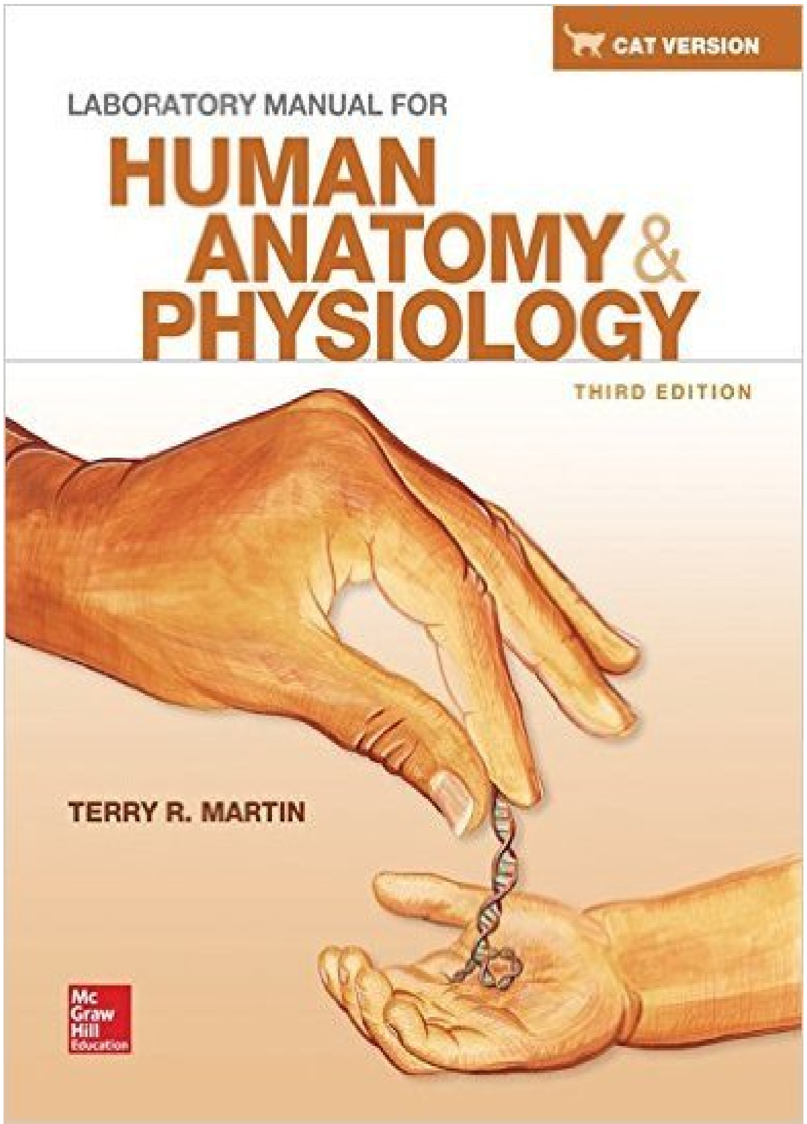

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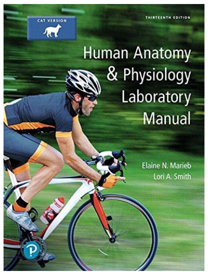

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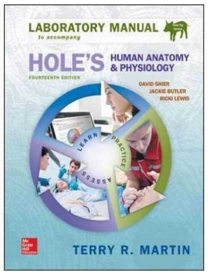

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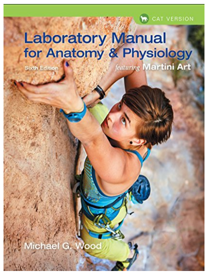

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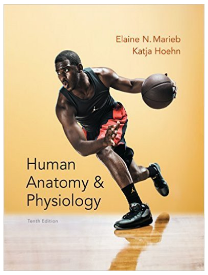

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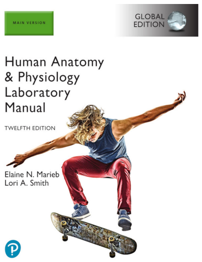

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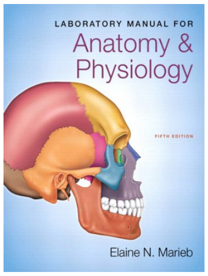

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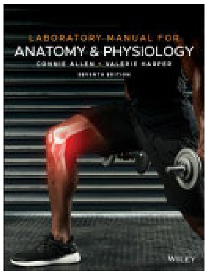

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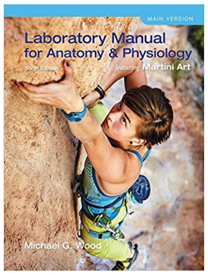

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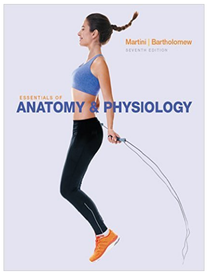

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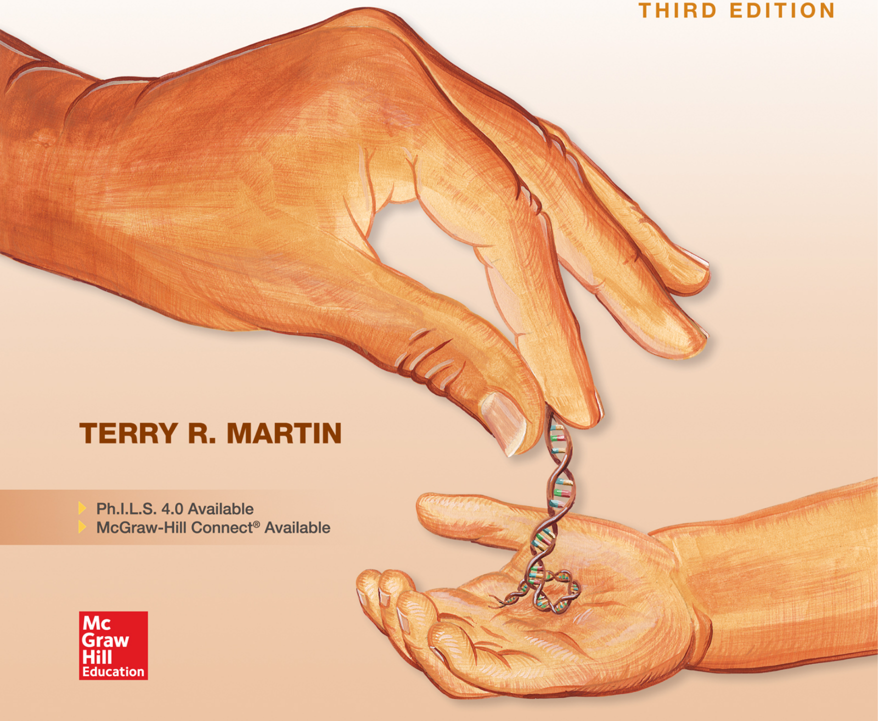

TERRY R. MARTIN

- Ph.I.L.S. 4.0 Available
- McGraw-Hill Connect® Available

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FEATURES OF THIS LABORATORY MANUAL

InTOUCH WITH Student Needs

- The procedures are clear, concise, and easy to follow. Relevant lists and summary tables present the contents efficiently. Histology micrographs and cadaver photos are incorporated in the appropriate locations within the associated labs.
- The pre-lab section includes quiz questions. It also directs the student to carefully read the introductory material and the entire lab to become familiar with its contents. If necessary, a textbook or lecture notes might be needed to supplement the concepts.
- **Terminologia Anatomica** is used as the source for universal terminology in this laboratory manual. Alternative names are included when a term is introduced for the first time.
- Laboratory assessments immediately follow each laboratory exercise.
- Histology photos are placed within the appropriate laboratory exercise.
- A section called "Study Skills for Anatomy and Physiology" is located in the front of this laboratory manual. This section was written by students enrolled in a Human Anatomy and Physiology course.
- Critical Thinking Activities are incorporated within most of the laboratory exercises to enhance valuable critical thinking skills that students need throughout their lives.
- Cadaver images are incorporated with dissection labs.

InTOUCH WITH Instructor Needs

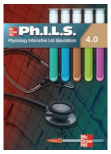
- The instructor will find digital assets for use in creating customized lectures, visually enhanced tests and quizzes, and other printed support material.
- A correlation guide for **Anatomy & Physiology REVEALED® (APR)** and the entire lab manual is available. Contact your McGraw-Hill Learning Technology Representative. Cadaver images from APR are included within many of the laboratory exercises.
- Some unique labs included are "Scientific Method and Measurements," "Chemistry of Life," "Fetal Skeleton," "Surface Anatomy," "Diabetic Physiology," and "Genetics."
- The annotated instructor's guide for *Laboratory Manual for Human Anatomy and Physiology* describes the purpose of the laboratory manual and its special features, provides suggestions for presenting the laboratory exercises to students, instructional approaches, a suggested time schedule, and annotated figures and assessments. It contains a "Student Safety Contract" and a "Student Informed Consent Form."
- Each laboratory exercise can be completed during a single laboratory session.

InTOUCH WITH Educational Needs

- Learning outcomes with icons (O) have matching assessments with icons (A) so students can be sure they have accomplished the laboratory exercise content. Outcomes and assessments include all levels of learning skills: remember, understand, apply, analyze, evaluate, and create.
- Assessment rubrics for entire laboratory assessments are included in Appendix 2.

InTOUCH WITH Technology

- Anatomy & Physiology REVEALED® 3.0

  Detailed cadaver photographs blended together with a state-of-the-art layering technique provide a uniquely interactive dissection experience.
- 

  Physiology Interactive Lab Simulations (Ph.I.L.S. 4.0) is included with the lab manual. Eleven lab simulations are interspersed throughout the lab manual. The correlation guide for all of the simulations is included in Appendix 3.
- BIOPAC Systems, Inc. BIOPAC© exercises are included on four different body systems. BIOPAC© systems use hardware and software for data acquisition, analysis, and recording of information for an individual.

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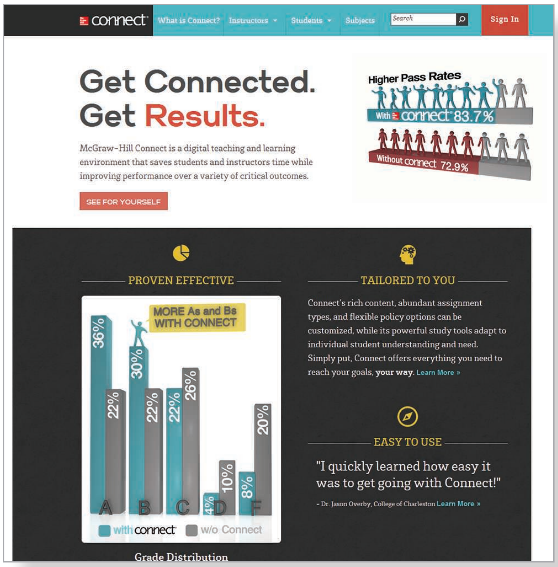
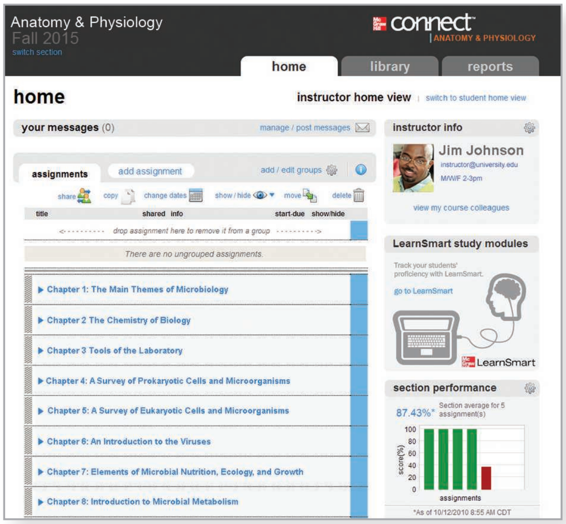
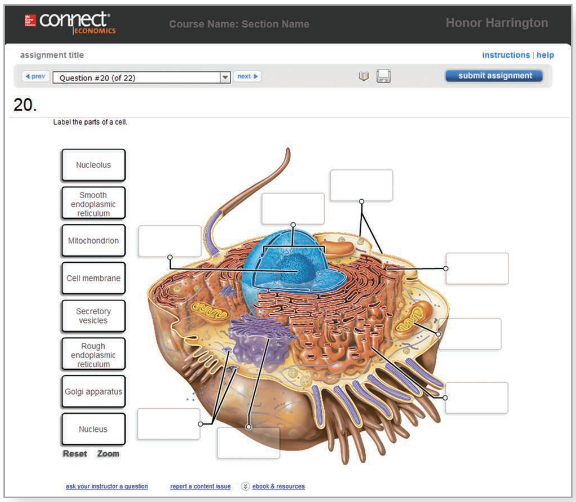


Save time with auto-graded assessments and tutorials

Fully editable, customizable, auto-graded interactive assignments using high-quality art from the lab manual, and animations and videos from a variety of sources take you way beyond multiple choice. Assignable content is available for every Learning Outcome in the lab manual. Extremely high quality content, includes case study modules, animated learning modules, and more!

Generate powerful data related to student performance based on question tagging for Learning Outcomes, HAPS topics and outcomes, specific topics, Bloom's level, and more.





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LEARNSMART PREP®

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The primary goal of LearnSmart Prep is to help students who are unprepared to take college-level courses. Using superadaptive technology, the program identifies what a student doesn't know and then provides "teachable moments" designed to mimic the office hour experience. When combined with a personalized learning plan, an unprepared or struggling student has all the tools needed to quickly and effectively learn the foundational knowledge and skills necessary to be successful in a college-level course.

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GUIDED TOUR THROUGH AN EXERCISE

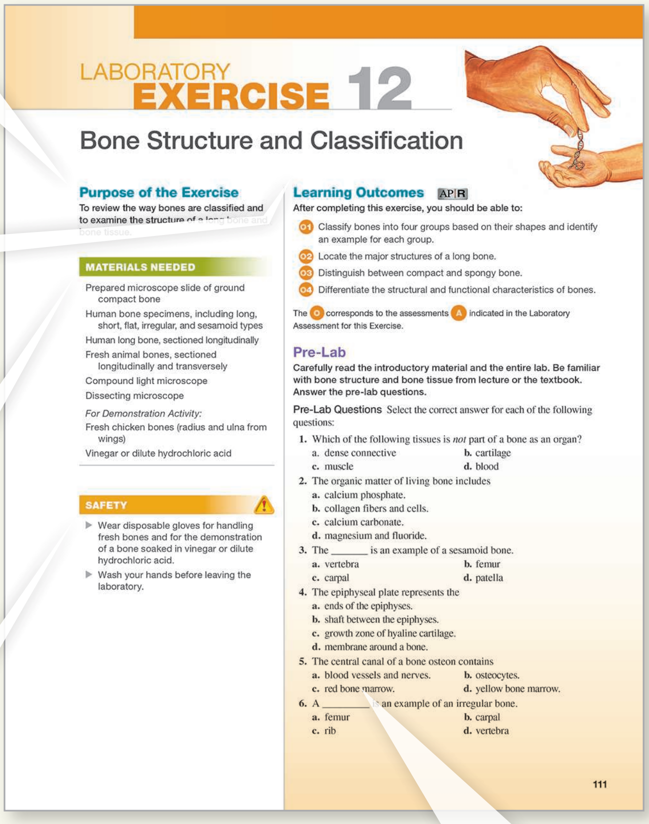
The laboratory exercises include a variety of special features that are designed to stimulate interest in the subject matter, to involve students in the learning process, and to guide them through the planned activities. These features include the following:

Purpose of the Exercise The purpose provides a statement about the intent of the exercise—that is, what will be accomplished.

Learning Outcomes The learning outcomes list what a student should be able to do after completing the exercise. Each learning outcome will have matching assessments indicated by the corresponding icon (A) in the laboratory exercise or the laboratory assessment.

Materials Needed This section lists the laboratory materials that are required to complete the exercise and to perform the demonstrations and learning extensions.

Safety A list of safety guidelines is included inside the front cover. Each lab session that requires special safety guidelines has a safety section. Your instructor might require some modifications of these guidelines.



LABORATORY EXERCISE 12

Bone Structure and Classification

Purpose of the Exercise

To review the way bones are classified and to examine the structure of a long bone and bone tissue.

MATERIALS NEEDED

Prepared microscope slide of ground compact bone
Human bone specimens, including long, short, flat, irregular, and sesamoid types
Human long bone, sectioned longitudinally
Fresh animal bones, sectioned longitudinally and transversely
Compound light microscope
Dissecting microscope

For Demonstration Activity:
Fresh chicken bones (radius and ulna from wings)
Vinegar or dilute hydrochloric acid

SAFETY

- Wear disposable gloves for handling fresh bones and for the demonstration of a bone soaked in vinegar or dilute hydrochloric acid.
- Wash your hands before leaving the laboratory.

Learning Outcomes APR

After completing this exercise, you should be able to:

O1 Classify bones into four groups based on their shapes and identify an example for each group.
O2 Locate the major structures of a long bone.
O3 Distinguish between compact and spongy bone.
O4 Differentiate the structural and functional characteristics of bones.

The (O) corresponds to the assessments (A) indicated in the Laboratory Assessment for this Exercise.

Pre-Lab

Carefully read the introductory material and the entire lab. Be familiar with bone structure and bone tissue from lecture or the textbook. Answer the pre-lab questions.

Pre-Lab Questions Select the correct answer for each of the following questions:

1. Which of the following tissues is *not* part of a bone as an organ?
   a. dense connective b. cartilage
   c. muscle d. blood
2. The organic matter of living bone includes
   a. calcium phosphate.
   b. collagen fibers and cells.
   c. calcium carbonate.
   d. magnesium and fluoride.
3. The _______ is an example of a sesamoid bone.
   a. vertebra b. femur
   c. carpal d. patella
4. The epiphyseal plate represents the
   a. ends of the epiphyses.
   b. shaft between the epiphyses.
   c. growth zone of hyaline cartilage.
   d. membrane around a bone.
5. The central canal of a bone osteon contains
   a. blood vessels and nerves. b. osteocytes.
   c. red bone marrow. d. yellow bone marrow.
6. A _________ is an example of an irregular bone.
   a. femur b. carpal
   c. rib d. vertebra

111

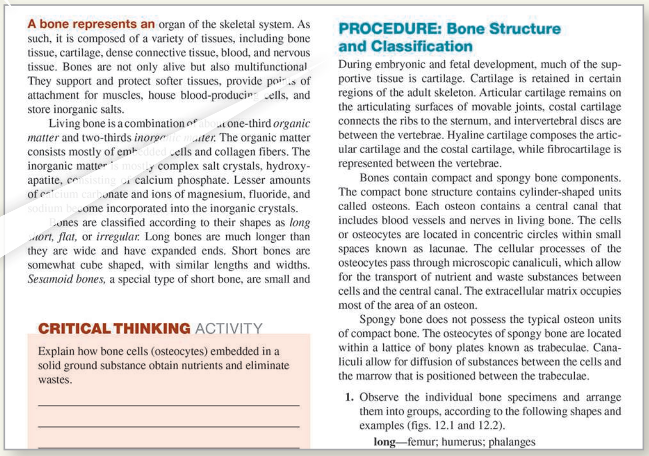
Introduction The introduction describes the subject of the exercise or the ideas that will be investigated. It includes all of the information needed to perform the laboratory exercise.

Pre-Lab The pre-lab includes quiz questions and directs the student to carefully read introductory material and examine the entire laboratory contents after becoming familiar with the topics from a textbook or lecture. After successfully answering the pre-lab questions, the student is prepared to become involved in the laboratory exercise.

Procedure The procedure provides a set of detailed instructions for accomplishing the planned laboratory activities. Usually these instructions are presented in outline form so that a student can proceed efficiently through the exercise in stepwise fashion.

The procedures include a wide variety of laboratory activities and, from time to time, direct the student to complete various tasks in the laboratory assessments.

There are also separate procedures in 11 labs that utilize Ph.I.L.S. 4.0.



A bone represents an organ of the skeletal system. As such, it is composed of a variety of tissues, including bone tissue, cartilage, dense connective tissue, blood, and nervous tissue. Bones are not only alive but also multifunctional. They support and protect softer tissues, provide points of attachment for muscles, house blood-producing cells, and store inorganic salts.

Living bone is a combination of about one-third *organic matter* and two-thirds *inorganic matter*. The organic matter consists mostly of embedded cells and collagen fibers. The inorganic matter is mostly complex salt crystals, hydroxyapatite, consisting of calcium phosphate. Lesser amounts of calcium carbonate and ions of magnesium, fluoride, and sodium become incorporated into the inorganic crystals.

Bones are classified according to their shapes as *long, short, flat,* or *irregular.* Long bones are much longer than they are wide and have expanded ends. Short bones are somewhat cube shaped, with similar lengths and widths. *Sesamoid bones,* a special type of short bone, are small and

CRITICAL THINKING ACTIVITY

Explain how bone cells (osteocytes) embedded in a solid ground substance obtain nutrients and eliminate wastes.

PROCEDURE: Bone Structure and Classification

During embryonic and fetal development, much of the supportive tissue is cartilage. Cartilage is retained in certain regions of the adult skeleton. Articular cartilage remains on the articulating surfaces of movable joints, costal cartilage connects the ribs to the sternum, and intervertebral discs are between the vertebrae. Hyaline cartilage composes the articular cartilage and the costal cartilage, while fibrocartilage is represented between the vertebrae.

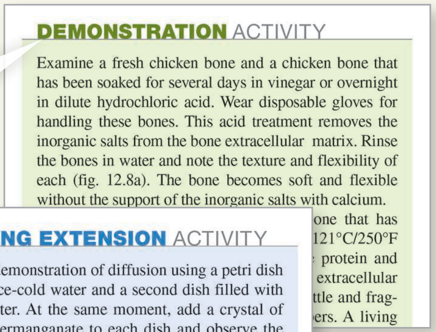
Bones contain compact and spongy bone components. The compact bone structure contains cylinder-shaped units called osteons. Each osteon contains a central canal that includes blood vessels and nerves in living bone. The cells or osteocytes are located in concentric circles within small spaces known as lacunae. The cellular processes of the osteocytes pass through microscopic canaliculi, which allow for the transport of nutrient and waste substances between cells and the central canal. The extracellular matrix occupies most of the area of an osteon.

Spongy bone does not possess the typical osteon units of compact bone. The osteocytes of spongy bone are located within a lattice of bony plates known as trabeculae. Canaliculi allow for diffusion of substances between the cells and the marrow that is positioned between the trabeculae.

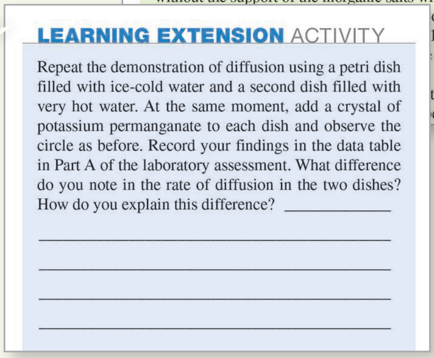
1. Observe the individual bone specimens and arrange them into groups, according to the following shapes and examples (figs. 12.1 and 12.2).

   long—femur; humerus; phalanges

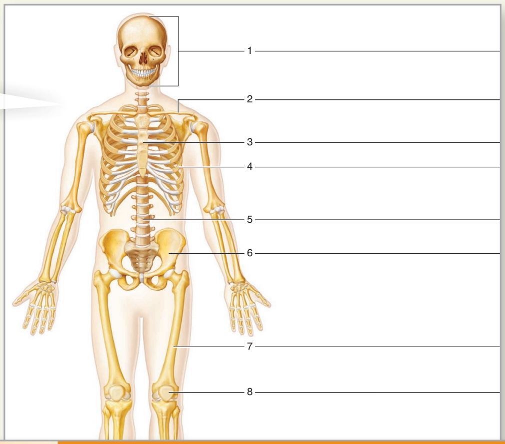
Demonstration Activities Demonstration activities appear in separate boxes. They describe specimens, specialized laboratory equipment, or other materials of interest that an instructor may want to display to enrich the student's laboratory experience.



Learning Extension Activities Learning extension activities also appear in separate boxes. They encourage students to extend their laboratory experiences. Some of these activities are open-ended in that they suggest the student plan an investigation or experiment and carry it out after receiving approval from the laboratory instructor. Some of the figures are illustrated as line art or in grayscale. This will allow colored pencils to be used as a visual learning activity to distinguish various structures.

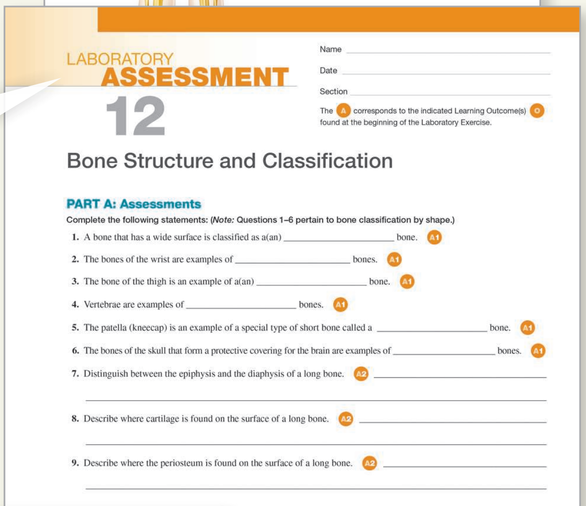


Illustrations Diagrams similar to those in a textbook often are used as aids for reviewing subject matter. Other illustrations provide visual instructions for performing steps in procedures or are used to identify parts of instruments or specimens. Micrographs are included to help students identify microscopic structures or to evaluate student understanding of tissues.

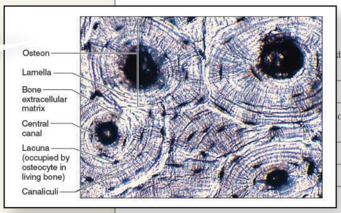


Laboratory Assessments A laboratory assessment form to be completed by the student immediately follows each exercise. These assessments include various types of review activities, spaces for sketches of microscopic objects, tables for recording observations and experimental results, and questions dealing with the analysis of such data.

As a result of these activities, students will develop a better understanding of the structural and functional characteristics of their bodies and will increase their skills in gathering information by observation and experimentation. By completing all of the assessments, students will be able to determine if they were able to accomplish all of the learning outcomes.



Histology Histology photos placed within the appropriate exercise.



CHANGES TO THIS EDITION

Global Changes

- New design incorporated in the laboratory exercises and assessments.
- Revised icons for Learning Outcomes and matching Assessments.
- BIOPAC exercises rewritten and an additional exercise added.
- Ph.I.L.S. 4.0 laboratory exercises revised and placed within a new design section at the end of the Laboratory Assessments.
- Added APR icons.
- Increased italicized terminology in laboratory introductory materials.

LABORATORY EXERCISE	TOPIC	CHANGE
1	Introductory material Table 1.1	Added independent and dependent variables Improved depth
2	Fig. 2.1b (anterior body cavity) Procedure B (organ systems) Fig. 2.5 (anatomical position) Figs. 2.6 and 2.10 (anatomical planes) Figs. 2.8a and 2.8b (surface regions) Assessments: Part E	Added figure Expanded components Improved labels Revised and improved labels Revised and full color Expanded components
4	Fig. 4.7 (wet mount steps)	Redrawn figure
5	Introductory material Figs. 5.1 and 5.4 (composite cell) Table 5.1 (cellular structures and functions) Fig. 5.5	Improved depth Expanded content and labels Added table New micrograph
6	Procedure B (osmosis) Figs. 6.2 (osmosis), 6.3 (filtration), and 6.4 (water bath) Assessments: Parts A, B, C, and D	Improved directions Redrawn figures Expanded and improved directions
7	Fig. 7.3 (prophase cell) Figs. 7.4 and 7.5 (mitosis phases) Fig. 7.6a (chromosomes) Fig. 7.7a and d (mitosis phases)	Revised labels Redrawn figures New figure Improved leader lines
8	Fig. 8.1c,d, and j (epithelial tissues) Fig. 8.1g and k (epithelial tissues) Table 8.1 (epithelial tissues)	New micrographs Added micrographs Expanded components
9	Fig. 9.1a,b, and h (connective tissues)	New micrographs
10	Fig. 10.2 (nervous tissue) Tables 10.1 and 10.2 (muscle and nervous tissues)	Added figure and micrograph Updated and expanded components
11	Table 11.2 (skin glands) Fig. 11.4 (fingernail) Fig. 11.5d (light skin) Assessments: Parts A, B, and C	Added table Added figure Added micrograph Expanded components
12	Fig. 12.6 (bone tissue) Fig. 12.7 (bone marrow locations)	New micrograph Added figure
13	Fig. 13.1a and b (bones) Assessments: Part A (bones)	New figures Improved figures in color
14	Fig. 14.7 (bones of orbit) Fig. 14.8 (paranasal sinuses) Assessments: Part D	Added figure Redrawn figure Expanded components
15	Figs. 15.1 (vertebrae) and 15.5 (rib) Assessments: Part B (Fig. 15.8)	Redrawn figures New radiograph of neck
16	Fig. 16.1 (shoulder and upper limb) Fig. 16.2 (clavicle) Assessments: Part C (Figs. 16.8 and 16.10)	Redrawn figure Added figure New radiographs of elbow and hand

LABORATORY EXERCISE	TOPIC	CHANGE
17	Assessments: Part C (Figs. 17.6, 17.7, and 17.8)	New radiographs of pelvis, knee, and foot
19	Procedure A and Table 19.1 (joints) Figs. 19.2 (synovial joint) Fig. 19.5a (supination/pronation) Assessments: Part B (Fig. 19.6) Assessments: Part E (Fig. 19.7)	Expanded and improved depth New figure New photograph Redrawn joints in full color Redrawn in full color and clarified movements
20	Procedure (skeletal muscle structure and function) Fig. 20.2b (neuromuscular junction) Table 20.1 (various roles of muscles) Assessments: Parts B and C	Expanded and improved depth Added figure Updated terminology and descriptions Revised and expanded components
22	Fig. 22.5 (scalene muscles)	Added figure
23	New organization Fig. 23.1 and Table 23.1 (respiratory muscles) Assessments: Parts A, B, C, D, and E (Figs. 23.7 and 23.8)	Content divided into Procedures A and B Added figure and table New organization of components and added respiratory muscle figures
24	Table 24.1 (vertebral muscles) Fig. 24.1 (vertebral column muscles) Assessments: Part A (Fig. 24.6) Assessments: Part B	Revised and expanded components Expanded and relabeled figure New figure of abdominal wall Expanded components
25	Fig. 25.5 (deep quadriceps muscles) Fig. 25.8 (lateral leg) Assessments: Part D (Fig. 25.11)	Added figure Redrawn figure Added figure of leg muscles of cadaver
26	Assessments: Part C (Fig. 26.10)	Redrawn figure of surface features
27	Fig. 27.4 (nervous tissue)	New micrograph
28	Meninges, Spinal Cord, and Spinal Nerves Figs. 28.1(meninges), 28.3 (spinal cord), and 28.5 (spinal nerves) Figs. 28.2 (spinal nerves), 28.4 (spinal cord), 28.6 (spinal nerves), and 28.13 (dermatomes) Figs. 28.7, 28.8, 28.9, 28.10, 28.11, and 28.12 (nerve plexuses) Table 28.1 (nerve plexuses) Assessments: Parts A, B, C, and D	New order of topics and expanded depth Relabeled figures Added figures Added figures Added table New order of assessments; Part D added
29	Reflex Arc and Somatic Reflexes Introductory material Figs. 29.1 (stretch reflex) and 29.2 (withdrawal reflex) Assessments: Part A table	Revised title Improved organization and depth New figures with improved depth Reorganized categories
30	Procedure A (cranial meninges) and Fig. 30.1 (cranial meninges) Table 30.3 (clinical tests of cranial nerves) Figs. 30.10 (olfactory nerve), 30.11 (trigeminal nerve), and 30.12 (facial nerve) Assessments: Part B Assessments: Part F	Added material and added figure Added table Added figures of selected cranial nerves Expanded components Added assessments of cranial nerves
31A	Reaction Time: BIOPAC Exercise	Added lab exercise
32	Figs. 32.3 and 32.4 (sheep brain) Fig. 32.7 (frontal section human brain)	Redrawn figures Added figure
34	Introductory material (smell and taste) Fig. 34.1 (olfactory epithelium) Fig. 34.3 (taste buds)	Updated and expanded components New micrograph and revised labels Added micrograph

CHANGES TO THIS EDITION

LABORATORY EXERCISE	TOPIC	CHANGE
35	Fig. 35.2a (eye muscles) Figs. 35.6 and 35.8 Fig. 35.7 (retina)	Added figure Redrawn figures Revised legend and labels
36	Fig. 36.4 (accommodation) Fig. 36.6 (color blindness plate)	Added figure New figure
37	Fig. 37.1 (auditory pathways)	Added figure
38	Fig. 38.1 (vestibular pathways)	Added figure
39	Figs. 39.4 (pituitary) and 39.12 (pancreas) Fig. 39.11 (pancreas)	New micrographs Redrawn figure and revised labels
40	Introductory material (diabetic physiology) Fig. 40.1 (pancreas) Assessments: Part C	Updated and expanded components Added micrograph Expanded components
41	Introductory material (blood cells) Figs. 41.1 and 41.6 (blood smears) Figs. 41.2 (clinic lab) and 41.3 (RBC)	Updated and expanded components Redrawn figures Added figures
42	Introductory material (blood components) Procedure B and Fig. 42.2 (Tallquist color scale) Fig. 42.4 (blood clot)	Updated and expanded depth Added Tallquist directions and figure Added micrograph
43	Procedure A and Figs. 43.1, 43.2, and 43.3 (agglutination figures) Figs. 43.4 and 43.6 (blood typing) Assessments: Part A	Updated and improved depth of agglutination reactions and added figures Redrawn figures Expanded components
44	Figs. 44.2 (heart) and 44.7 (cardiac muscle) Procedure B (sheep heart dissection) Figs. 44.9, 44.10, 44.11, and 44.12 (sheep hearts) Assessments: Part C (sheep hearts)	Added figure and micrograph Rewritten and expanded depth Added photographs Updated and expanded components
45	Figs. 45.1 (heart sounds), 45.3 (ECG), and 45.5 (ECG electrodes) Procedure B (electrocardiogram) Assessments: Part D and Fig. 45.7 (cardiac conduction)	Redrawn figures Updated content and materials used Expanded content and added figure
47	Fig. 47.3 (frog) Fig. 47.5 (pulmonary circuit) and 47.9b (celiac trunk) Figs. 47.12 and 47.14 (limb veins)	Redrawn figure Added figures Revised and added labels
48	Fig. 48.1 (pulse locations) Figs. 48.4 (sphygmomanometer) Fig. 48.5 (taking blood pressure)	New figure Redrawn figure New photograph
49	Fig. 49.2 (lymphatic capillaries) Fig. 49.3 (lymphatic valve) Fig. 49.9 (thymus)	Added figure Added micrograph New micrograph
50	Fig. 50.2b (upper respiratory) Fig. 50.3c (larynx sagittal view) Fig. 50.10 (lung) Assessments: Part C	Added figure of cadaver Added figure New micrograph Expanded components
51	Fig. 51.2 (Boyle's Law) Fig. 51.3 (air movements)	Added figure Redrawn figure
53	Procedure A (control of breathing) Fig. 53.1 (respiratory control) Fig. 53.2 (chemoreceptors) Table 53.1 ((muscles of respiration)	Updated and expanded depth Updated new figure Redrawn figure Added table

LABORATORY EXERCISE	TOPIC	CHANGE
54	Figs. 54.8 (pancreas), 54.9 (liver), and 54.11a (microscopic liver) Figs. 54.10 (pancreas) and 54.11b (liver) Figs. 54.15 (small intestine) and 54.16 (large intestine) Assessments: Part D	Added figures Added micrographs Revised micrograph labels Revised organization and expanded components
56	Fig. 56.2a (kidney) Procedure B (renal blood vessels) Figs. 56.5b (renal medulla), 56.7 (ureter), and 56.8 (urinary bladder)	Added figure Updated and expanded depth New micrographs
57	Introductory material and Procedure A (urinalysis) Figs. 57.1 (hydrometer) and 57.3 (urine sediments) Fig. 57.2 (reagent test strip) Assessments: Part A	Updated materials, new organization, and expanded components Redrawn figures Added figure Revised table and expanded components
58	Figs. 58.8 and 58.9 (male structures)	Redrawn figures
59	Introductory material and Procedure A (female structures and functions)	Expanded depth
60	Meiosis, Fertilization, and Early Development Introductory material and Procedure A (meiosis and fertilization) Fig. 60.1 (meiosis) Procedure B (sea urchin) Assessments: Parts A, B, and C	New title and order of components Added meiosis, updated, and expanded components Added figure Expanded content and materials used New organization and expanded components
62	Fig. 62.3 (cat skeleton) Fig. 62.5 Fig. 62.10 Figs. 62.21 and 62.24	Added photograph New APR cat muscle figure Improved image and added muscle labels Revised muscle labels
63	Assessments: Part C (Figs. 63.16 and 63.17)	Added APR cat cardiovascular figures
64	Figs. 64.3 and 64.5	Added APR cat respiratory figures
65	Fig. 65.2b Assessments: Part C (Fig. 65.5b)	Added APR cat digestive figure Added APR cat digestive figure
66	Figs. 66.2 and 66.5	Added APR cat urinary figures
67	Figs. 67.2b and 67.4b	Added APR cat reproductive figures

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Reviewers

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DEDICATION

McGraw-Hill Education along with Brian Kipp, Cynthia Prentice-Craver, and Phillip Snider wish to dedicate this lab manual to Terry and Sherrie Martin.

On Tuesday, May 6, 2014, the ribbon cutting took place for the Terry & Sherrie Martin Health Careers Wing at Kishwaukee College. A highlight of the Terry & Sherrie Martin Health Careers wing is the Nursing Simulation Lab. According to Kishwaukee College:

> High fidelity human patient simulators allow our students to have controlled, customized exposure to clinical events.

I am so proud to know Terry and Sherrie, who have done so much to help students become the health care professionals of tomorrow.

Ricki Lewis

Two of the most genuine people I have ever met. "I am truly blessed to have met and gotten to know Terry and Sherrie. The integrity that they both show is truly inspirational."

Phillip Snider Jr.

I consider it a true honor to have been able to work with Terry Martin for so many years. He is the epitome of an instructor, author, and friend. He and Sherrie have dedicated their lives to education. It's a true privilege to call them friends.

Fran Simon
Sr. Product Developer

Terry and Sherrie, Your dedication in teaching and support of your community is inspirational. Your hard work and generosity will be admired and genuinely appreciated by many for years to come. Congratulations!

Cindy Prentice-Craver

Terry and Sherrie Martin are two of those rare individuals who can take a sophisticated approach to solving a problem, yet keep things down to earth at the same time. I feel privileged to have them as colleagues and friends.

David Shier

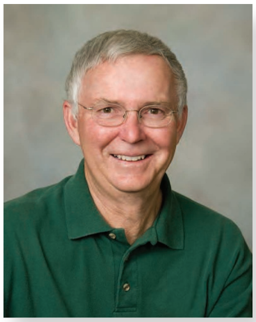
Terry and Sherry Martin have always helped people achieve their dreams, as educators and now with this legacy of the Health Careers Wing at Kishwaukee. I am proud and inspired to have them as friends.

Jackie Butler

Terry's passion for teaching is infectious and evident in his writing. His clear and approachable writing style is a perfect reflection of his personality. It is an honor to work with him.

Brian Kipp

ABOUT THE AUTHOR



TERRY R. MARTIN

This laboratory manual series is by Terry R. Martin of Kishwaukee College. Terry's teaching experience of over forty years, his interest in students and love for college instruction, and his innovative attitude and use of technology-based learning enhance the solid tradition of his other well-established laboratory manuals. Among Terry's awards are the Kishwaukee College Outstanding Educator, Phi Theta Kappa Outstanding Instructor Award, Kishwaukee College ICCTA Outstanding Educator Award, Who's Who Among America's Teachers, Kishwaukee College Faculty Board of Trustees Award of Excellence, Continued Excellence Award for Phi Theta Kappa Advisors, and John C. Roberts Community Service Award. Terry's professional memberships include the National Association of Biology Teachers, Illinois Association of Community College Biologists, Human Anatomy and Physiology Society, former Chicago Area Anatomy and Physiology Society (founding member), Phi Theta Kappa (honorary member), and Nature Conservancy. Terry revised the *Laboratory Manual to Accompany Hole's Human Anatomy and Physiology,* Fourteenth Edition, and revised the *Laboratory Manual to Accompany Hole's Essentials of Human Anatomy and Physiology*, Twelfth Edition. Terry teaches portions of EMT and paramedic classes and serves as a Faculty Consultant for Advanced Placement Biology examination readings. Terry has also been a faculty exchange member in Ireland. The author locally supports historical preservation, natural areas, scouting, and scholarship. We are pleased to have Terry continue the tradition of authoring laboratory manuals for McGraw-Hill Education.

The Editor

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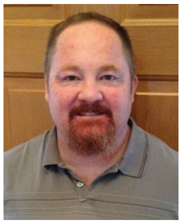


BRIAN H. KIPP is an associate professor in the Biomedical Sciences Department at Grand Valley State University, in west Michigan. He earned a B.S. in Biological Science from Saginaw Valley State University in 1995 and a Ph.D. in Biology from Wayne State University in 2001. At WSU Brian's research focused on organic oxidation-reduction reactions and the generation of reactive oxygen species. Since coming to GVSU in 2002 he has been very active in the development of one- and two-semester anatomy and physiology courses and is responsible for creating the undergraduate pre-clinical A&P course sequence.

Brian has also been at the forefront of new and developing pedagogical methods of instruction. Since he began working with McGraw-Hill in 2007 he has worked with APR, authored digital content for other physiology books and LearnSmart, and served as a digital faculty consultant.

Brian has been married to his best friend Nicole since 2000, and they have three beautiful children who keep them very busy. Currently, Brian and two of his children are practitioners of the martial art of Tang Soo Do and will be testing for their black belts in 2016. Brian's other passion is the sport of powerlifting, where he has won state, national, and world championships.

CYNTHIA PRENTICE-CRAVER is a contributing author to this third edition of Terry Martin's laboratory manual series. At Chemeketa Community College in Oregon since 1994, Cynthia's professional passion has been teaching Human Anatomy and Physiology. Thirteen years ago, Cynthia pioneered the development of hybrid and all-online Human Anatomy and Physiology courses. Her M.S. in Curriculum and Instruction, along with undergraduate and graduate coursework in biological sciences, were instrumental in the effective results of these nontraditional courses. She is thrilled to be using the human cadaver lab at Chemeketa Community College in her teaching of Human Anatomy and Physiology. Cynthia's experience includes Life Sciences program chair for eight years, serving on faculty hiring and Nursing application committees, and serving as reviewer and advisor of textbooks and digital products. She is a member of the Human Anatomy and Physiology Society (HAPS). Beyond her professional pursuits, Cynthia's passions include being active outdoors, volunteering in local schools and in youth athletics, competing in numerous half-marathons, and raising her five boys who are now young men.

PHILLIP D. SNIDER JR. has been teaching Human Anatomy and Physiology at Gadsden State Community College for the last ten years. He also began teaching Human Gross Anatomy and Pathophysiology in 2008. He was instrumental in implementing the gross anatomy course and lab at his college, which distinguished it as the only community college in the state of Alabama to have two fully functional gross anatomy labs. Among Phillip's awards are Who's Who Among America's Teachers, Alabama Community College Systems Chancellor's Award inductee, Leadership Development Institute graduate at Gadsden State, and National Institute for Staff and Organizational Development Excellence Award. Phillip's professional memberships include Human Anatomy and Physiology Society (HAPS) and the National Institute for Staff and Organizational Development. Phillip also serves as a Deputy Coroner for Calhoun County, Alabama.

TO THE STUDENT

The exercises in this laboratory manual will provide you with opportunities to observe various anatomical structures and to investigate certain physiological phenomena. Such experiences should help you relate specimens, models, microscope slides, and your body to what you have learned in the lecture and read about in the textbook.

Frequent variations exist in anatomical structures among humans. The illustrations in the laboratory manual represent normal (normal means the most common variation) anatomy. Variations from normal anatomy do not represent abnormal anatomy unless some function is impaired.

The following list of suggestions and study skills may make your laboratory activities more effective and profitable.

1. Prepare yourself before attending the laboratory session by reading the assigned exercise and reviewing the related sections of the textbook and lecture notes as indicated in the pre-lab section of the laboratory exercise. Answer the pre-lab questions. It is important to have some understanding of what will be done in the lab before you come to class.
2. Be on time. During the first few minutes of the laboratory meeting, the instructor often will provide verbal instructions. Make special note of any changes in materials to be used or procedures to be followed. Also listen carefully for information about special techniques to be used and precautions to be taken.
3. Keep your work area clean and your materials neatly arranged so that you can locate needed items. This will enable you to proceed efficiently and will reduce the chances of making mistakes.
4. Pay particular attention to the purpose of the exercise, which states what you are to accomplish in general terms, and to the learning outcomes, which list what you should be able to do as a result of the laboratory experience. Then, before you leave the class, review the outcomes and make sure that you can perform all of the assessments.
5. Precisely follow the directions in the procedure and proceed only when you understand them clearly. Do not improvise procedures unless you have the approval of the laboratory instructor. Ask questions if you do not understand exactly what you are supposed to do and why you are doing it.
6. Handle all laboratory materials with care. Some of the materials are fragile and expensive to replace. Whenever you have questions about the proper treatment of equipment, ask the instructor.
7. Treat all living specimens humanely and try to minimize any discomfort they might experience.
8. Although at times you might work with a laboratory partner or a small group, try to remain independent when you are making observations, drawing conclusions, and completing the activities in the laboratory reports.
9. Record your observations immediately after making them. In most cases, such data can be entered in spaces provided in the laboratory assessments.
10. Read the instructions for each section of the laboratory assessment before you begin to complete it. Think about the questions before you answer them. Your responses should be based on logical reasoning and phrased in clear and concise language.
11. At the end of each laboratory period, clean your work area and the instruments you have used. Return all materials to their proper places and dispose of wastes, including glassware or microscope slides that have become contaminated with human blood or body fluids, as directed by the laboratory instructor. Wash your hands thoroughly before leaving the laboratory.

Study Skills for Anatomy and Physiology

Students have found that certain study skills worked well for them while enrolled in Human Anatomy and Physiology. Although everyone has his or her learning style, there are techniques that work well for most students. Using some of the skills listed here can make your course more enjoyable and rewarding.

1. **Time management:** Prepare monthly, weekly, and daily schedules. Include dates of quizzes, exams, and projects on the calendar. On your daily schedule, budget several short study periods. Daily repetition alleviates cramming for exams. Prioritize your tasks so that you still have time for work and leisure activities. Find an appropriate study atmosphere with minimum distractions.
2. **Note taking:** Look for the main ideas and briefly express them in your own words. Organize, edit, and review your notes soon after the lecture. Add textbook information to your notes as you reorganize them. Underline or highlight with different colors the important points, major headings, and key terms. Study your notes daily, as they provide sequential building blocks of the course content.
3. **Chunking:** Organize information into logical groups or categories. Study and master one chunk of information at

a time. For example, study the bones of the upper limb, lower limb, trunk, and head as separate study tasks.

4. **Mnemonic devices:** An *acrostic* is a combination of association and imagery to aid your memory. It is often in the form of a poem, rhyme, or jingle in which the first letter of each word corresponds to the first letters of the words you need to remember. **S**o **L**ong **T**op **P**art, **H**ere **C**omes **T**he **T**humb is an example of such a mnemonic device for remembering the eight carpals in a correct sequence. *Acronyms* are words formed by the first letters of the items to remember. *IPMAT* is an example of this type of mnemonic device to help you remember the phases of the cell cycle in the correct sequence. Try to create some of your own.
5. **Note cards/flash cards:** Make your own. Add labels and colors to enhance the material. Keep them with you; study them often and for short periods. Concentrate on a small number of cards at one time. Shuffle your cards and have someone quiz you on their content. As you become familiar with the material, you can set aside cards that don't require additional mastery.
6. **Recording and recitation:** An auditory learner can benefit by recording lectures and review sessions with a cassette recorder. Many students listen to the taped sessions as they drive or just before going to bed. Reading your notes aloud can help also. Explain the material to anyone (even if there are no listeners). Talk about anatomy and physiology in everyday conversations.
7. **Study groups:** Small study groups that meet periodically to review course material and compare notes have helped and encouraged many students. However, keep the group on the task at hand. Work as a team and alternate leaders. This group often becomes a support group.

Practice sound study skills during your anatomy and physiology endeavor.

The Use of Animals in Biology Education*

The National Association of Biology Teachers (NABT) believes that the study of organisms, including nonhuman animals, is essential to the understanding of life on Earth. NABT recommends the prudent and responsible use of animals in the life science classroom. NABT believes that biology teachers should foster a respect for life. Biology teachers also should teach about the interrelationship and interdependency of all things.

Classroom experiences that involve nonhuman animals range from observation to dissection. NABT supports these experiences so long as they are conducted within the long-established guidelines of proper care and use of animals, as developed by the scientific and educational community.

As with any instructional activity, the use of nonhuman animals in the biology classroom must have sound educational objectives. Any use of animals, whether for observation or dissection, must convey substantive knowledge of biology. NABT believes that biology teachers are in the best position to make this determination for their students.

NABT acknowledges that no alternative can substitute for the actual experience of dissection or other use of animals and urges teachers to be aware of the limitations of alternatives. When the teacher determines that the most effective means to meet the objectives of the class do not require dissection, NABT accepts the use of alternatives to dissection, including models and the various forms of multimedia. The Association encourages teachers to be sensitive to substantive student objections to dissection and to consider providing appropriate lessons for those students where necessary.

To implement this policy, NABT endorses and adopts the "Principles and Guidelines for the Use of Animals in Precollege Education" of the Institute of Laboratory Animals Resources (National Research Council). Copies of the "Principles and Guidelines" may be obtained from the ILAR (2101 Constitution Avenue, NW, Washington, DC 20418; 202-334-2590).

*Adopted by the Board of Directors in October 1995. This policy supersedes and replaces all previous NABT statements regarding animals in biology education.

LABORATORY
EXERCISE 1

Scientific Method and Measurements

Purpose of the Exercise

To become familiar with the scientific method of investigation, learn how to formulate sound conclusions, and provide opportunities to use the metric system of measurements.

MATERIALS NEEDED

Meterstick
Calculator
Human skeleton

Learning Outcomes

After completing this exercise, you should be able to:

O1 Convert English measurements to the metric system, and vice versa.

O2 Calculate expected upper limb length and actual percentage of height from recorded upper limb lengths and heights.

O3 Apply the scientific method to test the validity of a hypothesis concerning the direct, linear relationship between human upper limb length and height.

O4 Design an experiment, formulate a hypothesis, and test it using the scientific method.

The O corresponds to the assessments A indicated in the Laboratory Assessment for this Exercise.

Pre-Lab

Carefully read the introductory material and examine the entire lab. Be familiar with the scientific method from lecture or the textbook. Answer the pre-lab questions.

Pre-Lab Questions Select the correct answer for each of the following questions:

1. To explain biological phenomena, scientists use a technique called
a. the scientific method. **b.** the scientific law.
c. conclusions. **d.** measurements.

2. Which of the following represents the correct sequence of the scientific method?
a. analysis of data, conclusions, observations, experiment, hypothesis
b. conclusions, experiment, hypothesis, analysis of data, observations
c. observations, hypothesis, experiment, analysis of data, conclusions
d. hypothesis, observations, experiment, analysis of data, conclusions

3. A hypothesis, verified continuously from experiments by many investigators, can become known as a
a. control. **b.** variable.
c. valid result. **d.** theory.

4. The most likely scientific unit for measuring the height of a person would be
a. feet. **b.** centimeters.
c. inches. **d.** kilometers.

5. Which of the following is *not* a unit of the metric system of measurements?
a. centimeters **b.** liters
c. inches **d.** millimeters

6. The hypothesis is formulated from the results of the experiment.
   a. True _____ **b.** False _____
7. A centimeter represents an example of a metric unit of length.
   a. True _____ **b.** False _____

Scientific investigation involves a series of logical steps to arrive at explanations for various biological phenomena. It reflects a long history of asking questions and searching for knowledge. This technique, called the *scientific method,* is used in all disciplines of science. It allows scientists to draw logical and reliable conclusions.

The scientific method begins with making *observations* related to the topic under investigation. This step commonly involves the accumulation of previously acquired information and/or your observations of the phenomenon. These observations are used to formulate a tentative explanation known as the *hypothesis.* An important attribute of a hypothesis is that it must be testable. The testing of the proposed hypothesis involves designing and performing a carefully controlled *experiment* to obtain data that can be used to support, reject, or modify the hypothesis. During the experiment to test the proposed hypothesis, it is important to be able to examine only a single changeable factor, known as a *variable.* An *independent variable* is one that can be changed, but is determined before the experiment occurs; a *dependent variable* is determined from the results of the experiment.

An *analysis of data* is conducted using sufficient information collected during the experiment. Data analysis may include organization and presentation of data as tables, graphs, and drawings. From the interpretation of the data analysis, *conclusions* are drawn. (If the data do not support the hypothesis, you must reexamine the experimental design and the data, and if needed develop a new hypothesis.) The final presentation of the information is made from the conclusions. Results and conclusions are presented to the scientific community for evaluation through peer reviews, presentations at professional meetings, and published articles. If many investigators working independently can validate the hypothesis by arriving at the same conclusions, the explanation can become a *theory.* A theory serves as the explanation from a summary of known experiments and supporting evidence unless it is disproved by new information. The five components of the scientific method are summarized as

Observations
↓
Hypothesis
↓
Experiment
↓
Analysis of data
↓
Conclusions

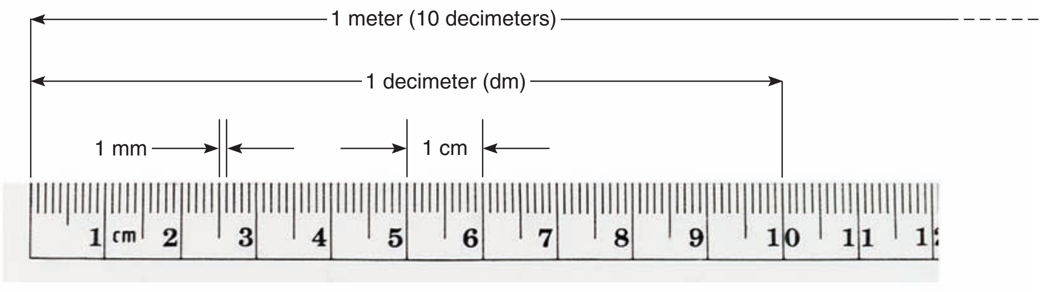
Metric measurements are characteristic tools of scientific investigations. The English system of measurements is often used in the United States, so the investigator must make conversions from the English system to the metric system. Table 1.1 provides the conversion factors necessary to change from English to metric units.

PROCEDURE A: Using the Steps of the Scientific Method

This procedure represents a specific example of the order of the steps utilized in the scientific method. Each of the steps for this procedure will guide you through the proper sequence in an efficient pathway.

1. A correlation exists between the length of the upper and lower limbs and the height (stature) of an individual. For example, a person who has long upper limbs (the arm, forearm, and hand combined) tends to be tall. Make some visual observations of other people in your class to observe a possible correlation.
2. From such observations, the following hypothesis can be formulated: The length of a person's upper limb is equal to 0.4 (40%) of the height of the person. To test this hypothesis, perform the following experiment.
3. Use a meterstick (fig. 1.1) to measure an upper limb length of ten subjects. Place the meterstick in the axilla (armpit) and record the length in centimeters to the end of the longest finger (fig. 1.2). Obtain the height of

FIGURE 1.1 Metric ruler with metric lengths indicated. A meterstick length would be 100 centimeters (10 decimeters). (The image size is approximately to scale.)



Metric ruler

Table 1.1 Metric Measurement System and Conversions

Measurement	Unit & Abbreviation	Metric Equivalent	Conversion Factor Metric to English (approximate)	Conversion Factor English to Metric (approximate)
Length	1 kilometer (km)	1,000 (10^3) m	1 km = 0.62 mile	1 mile = 1.61 km
	1 meter (m)	100 (10^2) cm 1,000 (10^3) mm	1 m = 1.1 yards = 3.3 feet = 39.4 inches	1 yard = 0.9 m 1 foot = 0.3 m
	1 decimeter (dm)	0.1 (10^{-1}) m	1 dm = 3.94 inches	1 inch = 0.25 dm
	1 centimeter (cm)	0.01 (10^{-2}) m	1 cm = 0.4 inches	1 foot = 30.5 cm 1 inch = 2.54 cm
	1 millimeter (mm)	0.001 (10^{-3}) m 0.1 (10^{-1}) cm	1 mm = 0.04 inches	
	1 micrometer (μm)	0.000001 (10^{-6}) m 0.001 (10^{-3}) mm		
Mass	1 metric ton (t)	1,000 (10^3) kg	1 t = 1.1 ton	1 ton = 0.91 t
	1 kilogram (kg)	1,000 (10^3) g	1 kg = 2.2 pounds	1 pound = 0.45 kg
	1 gram (g)	1,000 (10^3) mg	1 g = 0.04 ounce	1 pound = 454 g 1 ounce = 28.35 g
	1 milligram (mg)	0.001 (10^{-3}) g		
Volume (liquids and gases)	1 liter (L)	1,000 (10^3) mL	1 L = 1.06 quarts	1 gallon = 3.78 L 1 quart = 0.95 L
	1 milliliter (mL)	0.001 (10^{-3}) L 1 cubic centimeter (cc or cm^3)	1 mL = 0.03 fluid ounce 1 mL = 1/5 teaspoon 1 mL = 15–16 drops	1 quart = 946 mL 1 fluid ounce = 29.6 mL 1 teaspoon = 5 mL
Time	1 second (s)	1/60 minute	same	same
	1 millisecond (ms)	0.001 (10^{-3}) s	same	same
Temperature	Degrees Celsius (°C)		°F = 9/5 °C + 32	°C = 5/9 (°F – 32)

FIGURE 1.2 Measurement of upper limb length.

each person in centimeters by measuring them without shoes against a wall (fig. 1.3). The height of each person can also be calculated by multiplying each individual's height in inches by 2.54 to obtain his/her height in centimeters. Record all your measurements in Part A of Laboratory Assessment 1.

4. The data collected from all of the measurements can now be analyzed. The expected (predicted) correlation between upper limb length and height is determined using the following equation:

   Height × 0.4 = expected upper limb length

   The observed (actual) correlation to be used to test the hypothesis is determined by

   Length of upper limb/height = actual % of height

5. A graph is an excellent way to display a visual representation of the data. Plot the subjects' data in Part A of the laboratory assessment. Plot the upper limb length of each subject on the x-axis (independent variable) and the height of each person on the y-axis (dependent variable). A line is already located on the graph that represents a hypothetical relationship of 0.4 (40%) upper limb length compared to height. This is a graphic representation of the original hypothesis.
6. Compare the distribution of all of the points (actual height and upper limb length) that you placed on the graph with the distribution of the expected correlation represented by the hypothesis.
7. Complete Part A of the laboratory assessment.

FIGURE 1.3 Measurement of height.

PROCEDURE B: Design an Experiment

You have completed the steps of the scientific method with guidance directions in Procedure A. This procedure will allow for less guidance and more flexibility using the scientific method.

CRITICAL THINKING ACTIVITY

You have probably concluded that there is some correlation of the length of body parts to height. Often, when a skeleton is found, it is not complete. It is occasionally feasible to use the length of a single bone to estimate the height of an individual. Observe human skeletons and locate the humerus bone in an upper limb or the femur bone in a lower limb. Use your observations to identify a mathematical relationship between the length of the humerus or femur and height. Formulate a hypothesis that can be tested. Make measurements, analyze data, and develop a conclusion from your experiment. Complete Part B of the laboratory assessment.

LABORATORY
ASSESSMENT 1

Name ______________________________

Date ______________________________

Section ______________________________

The (A) corresponds to the indicated Learning Outcome(s) (O) found at the beginning of the Laboratory Exercise.

Scientific Method and Measurements

PART A: Assessments

1. Record measurements for the upper limb length and height of ten subjects. Use a calculator to determine the expected upper limb length and the actual percentage (as a decimal or a percentage) of the height for the ten subjects. Record your results in the following table. A2

Subject	Measured Upper Limb Length (cm)	Height* (cm)	Height × 0.4 = Expected Upper Limb Length (cm)	Actual % of Height = Measured Upper Limb Length (cm)/ Height (cm)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

*The height of each person can be calculated by multiplying each individual's height in inches by 2.54 to obtain his/her height in centimeters. A1

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hell of a note!” Laugh it off pleasantly and apologize to the hostess.

*   *   *

Daffy Dill—Your question is rather absurd and my answer is NO, I have never heard a porcupine for its mate. But I have seen a gopher go for a gopher.

*   *   *

Oliver Towne—I can’t quite agree with you as to the world’s greatest historical event. How about the time that Antony made a date with Cleopatra?

*   *   *

J. C. R.—Yes, you are correct. The women’s wearing apparel nowadays are held up by nothing more than a string of beads on one side and the kindness of heaven on the other.

*   *   *

Happy Harriet—It is quite true that a teakettle full of water sings, but whoinel wants to be a teakettle.

*   *   *

James B.—I am not positive as to the number of years the government has been trying to obliterate moonshining in Kentucky. I do know, however, that they’re taking in lots of territory now.

*   *   *

Hubby: “Let’s name our darling baby ‘Prohibition.’”

Wifelets: “I should say not. He’ll never be a ‘dry’.”

*   *   *

Some Persuader

Brumbaugh—"I can't see why Bert Kitchins married that ugly Miss Vanderpeel. Her money would not have been an inducement to me!"

Gimble—"No? Well, her father's shotgun might have persuaded even you."

*　　*　　*

Too Bad

Pelican: "Did you hear about the arrest of William Jennings Bryan?"

Belican: "No, what was it all about?"

Helican: "For feeling out the women delegation to see if they were wet or dry."

*　　*　　*

Or a Second Bill Sunday

A father, wishing to satisfy himself as to the future prospects of his son, decided to make the following test:—"Now," he said, "I will put here, where he will see them the first thing when he comes in, a Bible, some money, and a bottle of whiskey. If he takes the Bible he will be a preacher, if he takes the money he will be a business man, and if he takes the whiskey he will be no good." Having thus decided on the plan, he arranged the articles and concealed himself to await the son and watch results. Presently in came the boy, saw the money and put it in his pocket, took up the bottle of whiskey and drank it, put the Bible under his arm and walked out whistling. "My gracious!" exclaimed the father, "he will soon be a United States Senator."

*   *   *

Doggonit

A farmer friend of mine was standing in the road with a gun tucked under his arm and an old dog at his side. He was directly in the path of a motor car. The chauffeur sounded his horn, but the dog did not move—until he was struck. After that he did not move.

The automobile stopped and one of the men got out and came forward. He had once paid a farmer $10 for killing a calf that belonged to another farmer. This time he was wary.

"Was that your dog?"

"Yes."

"You own him?"

"Yes."

"Looks as if we'd killed him."

"Certainly looks so."

"Very valuable dog?"

"Well, not so very."

"Will $5 satisfy you?"

"Yes."

"Well, then, here you are." He handed a $5 bill to the man with the gun, and said pleasantly, "I'm sorry to have broken up your hunt."

"I wasn't going hunting," replied the other as he pocketed the bill.

"Not going hunting? Then what were you doing with the dog and the gun?"

"Going down to the river to shoot the dog."

*   *   *

Too many women look upon a marriage certificate as a license to operate a holdup game.

*   *   *

Pickled Puppies

A lady entering a crowded train, requested a little boy if she might put his basket, which he had beside him, up in the rack so that she might sit there. He assented willingly.

A short time later the lady remarked, “Sonny, I’m afraid your pickles are leaking.”

Little boy, disgustedly, “Them ain’t pickles, lady, them’s puppies.”

*   *   *

Miss Marcella had a cat,
   The cat she had a feller;
Their backyard concerts so annoyed
   Ma made Marcella sell her.

*   *   *

Speaking of society, we heard a good one the other night. A dude and his lady friend were tripping lightly back from the reception room when a rather stout lady whose gown started somewhere close to the ground and never could get strength enough to get any nearer to her shoulders, bumped into him. The dude was peeved and said aloud to his lady friend: “Like Balaam’s ass, some people are always getting in the way.” The fat dame, quick to retort, replied, “You are wrong. It was the angel who got in the way and the ass that spoke.”

*   *   *

Sayings of the Famous

Rastus Johnsing—"Mandy, the only thing that ever kept me a good man was your won't power and my will power."

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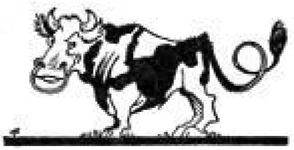

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